Presidential Commission
for the Study of Bioethical Issues

TRANSCRIPT

Ethics

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Amy Gutmann:
Ladies and gentlemen, if you would, please, take your seats, we're ready to get started. While Diane is standing, I'd like to introduce her as your designated federal officer which makes this meeting legal.

Good morning, I'm Amy Gutmann, and I'm President of the University of Pennsylvania and the Chair of the Presidential Commission for the Study of Bioethical Issues. Our Vice Chair, Jim Wagner, will introduce the first session.

We are now starting day two of our meeting on synthetic biology. Yesterday, we heard from some of our leading experts in synthetic biology. We received a very clear overview of the science. We learned about its likely future applications and benefits. We heard about some of the potential risks and other ethical concerns.

Let me emphasize that this is the first of three meetings on this topic. We have purposefully planned this meeting to be a primer or an overview. We will take deep dives in September at our next meeting at the University of Pennsylvania in Philadelphia, and also open to the public, September 13th and 14th and at our November meeting at Emory University in Atlanta.

Today, we will continue to look at the ethical implications of this technology as well as the issues related to federal oversight and regulation. Jim Wagner, President of Emory University and Vice Chair of the Commission, will introduce the first panel.

Jim Wagner:
Thank you. Thank you, Amy. Good morning to everyone. Good morning to our commissioners, to our experts. Thank you all for being here. Excited to get this second day going, and hope it will be marked with the same frank and eager level of discussion that we enjoyed yesterday.

This morning, as Amy has said, our first session is on ethics. We ended with a session on ethics yesterday, and we'll start today's panel hearing from David Rejeski who directs the Woodrow Wilson Center's Program for Science and Technology Innovation as well as its Synthetic Biology Project. Before he joined the Wilson Center, Mr.

Rejeski worked for the White House Office of Science and Technology on a variety of technology-related issues.

David, welcome this morning. We look forward to your comments.

David Rejeski:
Well, thank you. It's a pleasure to be here. I'd like to thank Dr. Gutmann and the whole Commission and also-- also thank your staff which I think have done a great job in terms of supporting everyone who has been involved.

I've got some slides that I'm going to go through. Let me just start by saying that we have devoted about six years of our time into my project trying to essentially bring the voice, or voices, of the public into the conversation about science policy on emerging technologies. So we started with nanotechnology, we've continued with nanotechnology, and have now added synthetic biology.

In terms of how we do this, it's pretty easy: we talk to them. We go out with a fairly intensive and structured discussions with people all around the country. We have run lots of focus groups in Spokane, Washington; Dallas, Texas; Cleveland, Ohio; and Baltimore, Maryland. Every year we do an annual survey with heart research. We're going to be doing a new one in August on synthetic biology in which we'll be asking questions about what happens if next year we produce our flu vaccine with synthetic biology. It might be interesting to get public input on that question. We also do a lot of partnering with other groups that are doing similar kinds of research in this space. And some work on media. Let me jump in and give you a sense of what we found out.

Big question, what is this? We have been grappling with this for two days. So we ask people, how much have you ever heard about synthetic biology? These are the figures from 2008 and 2009. They have actually increased somewhat. But at this point in time, 80% of the American public has heard little or nothing about synthetic biology. So who they hear from, what the message is, and how they hear it could have a huge impact on future trajectories of the technology and our ability to use it. So you're in this, I think, very interesting space right now where people don't know much. Having said that, this is a

complex word and it tends to, I think, elicit a lot of concerns as soon as people hear it. It's different than nanotechnology. People wonder, what is that?

Synthetic biology, people think about this through analogy. And the train goes something like this: Synthetic biology, is that like artificial life? Is that cloning? Is that stem cells? Is that GMOs? Within about 15 seconds, you've hit every third-reel issue that you might possibly hit: "The term synthetic biology makes me think of genetic engineering and something lab-grown." "Cloning is the image I think of." "I think about molecular compounds and playing God." This is the public speaking right now. So this is kind of how you're starting off. In order to kind of get around this, what we've done is, we've tried to kind of immediately focus people on applications. We go past the science right into application.

Last year, we did a lot of work on biofuels because that seems to be coming down the track very quickly. And the people's reactions to biofuels and the use of synthetic organisms and the engineering of metabolic pathways is largely one of conditional optimism: "I think this is pretty good, but…" And it's the "buts" that are interesting. "This is positive. It all sounds wonderful, but my concern is that maybe by doing this, we'll create something that we can't control." Here's another "but": "Once you start doing this, you open a Pandora's Box and we may start doing this for things that I don't approve of. Where are the boundaries?"

So when you start looking at this, and you break it down, you find about a 30/30 split. People have concerns about the leakage into bioweapons, the moral issues about artificial life. There's a lot of concerns about these environmental issues. Could it move in horizontal gene transfer?

The other thing we played with last year was it seemed inevitable almost that somebody was going to create some form of synthetic life. We weren't sure who would do it, when it would happen, so we played with that question, And here's what came out: almost 100% of the people said more should be done to inform the public about this research. So you've got a fairly strong mandate. "The federal government should regulate this research." 2/3 of the people said that. "I'm

worried about this." Over half. "I'm excited about it." Less than half.

This tracks fairly well with what's going on in Europe. Here's a recent statement that came in Nature magazine: "Without effective public engagement, there will be no synthetic biology in Europe." Pretty strong statement I think. "Artificial life needs regulation." So this will give you some idea. I think there's a huge, huge hunger for public dialogue on this issue.

The dark horse in synthetic biology's future is trust, and whether we will trust the people that are essentially developing the technology, promoting the technology, or doing oversight on the technology.

And, so, for the past three years, we've actually tracked trust in agencies. You can see where the government agencies are kind of oscillating in a 50% to 60% range. This is a broad question about whether the public trusts these agencies to maximize benefits and minimize risks, which is kind of what the Commission is about. We added the DOE last year because of the biofuels work. The agencies beat the businesses.

So this issue of who wins in a global race I think with synthetic biology, it will have a lot to do with how much social capital you have in your society. There's huge variations. There's much more trust, for instance, in government and corporations in China right now than there is in the U.S. So this trust issue is sort of lurking in the background, but it's something we'll look at again this year.

We have asked people, well, how do we build trust with nanotech? We're going to be doing this in August with synthetic biology. We found essentially no public support for a moratorium on research. It always comes up, "let's shut the system down". But we also found no public support really for self-regulation by industry. So this idea that industry is going to just look after itself and everything will be fine, there's just not a lot of public belief that that's going to happen.

When we asked people very specifically "how can we build public confidence?" the thing that happens is 80% of their responses converge around three answers. They want (1) greater transparency and disclosure about science, (2) they want pre-market testing. There's this

feeling, there's this fear, that we're taking technologies and pushing them into the market without doing the due diligence. The government isn't doing it, the corporations aren't doing it. And they also like (3) the idea of third-party testing. So they bring up issues, they bring up examples like Consumers Union or Underwriters Lab or people who are essentially above the fray or the National Academy of Sciences.

Having industry do the testing is probably not going to work here. Okay, so then we sort of asked, where are people getting these ideas? Because they certainly aren't reading peer-reviewed literature, at least most people aren't.

So here's the great filter. Some of you might know this Gary Larson cartoon. This is a scientist on the top and the media on the bottom. Now, if you think this is an exaggeration, this is what came out a few weeks ago. This is an analysis we did on the headlines in major press outlets in the U.S. The size of the words essentially represent the frequency of their use. A lot of people just skim the headlines anyway. So this is what they kind of got out of this. "Craig creates synthetic life."

[AUDIENCE LAUGHTER]

Now, if you think this is just an American phenomenon, we went back a few weeks ago and took a bigger sample. We looked at the U.S., the U.K. and Germany. That was the U.S. "It's about synthetic life, folks." This is the U.K., "It's about synthetic life." This is Germany, "Artificial life and Craig Venter." So this is working constantly. I'll come back to this a little later in terms of whether this is problematic and how to fix it.

The other thing that happens is there's very different ways of covering it, we found in the U.S. and in the European Union. This is work that my colleague Eleanor Pauwels has done. We basically looked at press for five years. This is the U.S. press. We tend to be very bullish on benefits. This is the same pattern we have with nanotechnology and GMOs. A lot of the articles talk about the benefits; very few talk about the risks.

This is the European press, a little bit more balanced. The thing that's quite surprising is then you break the things down into issues. These are the issues that appeared in the American press. Synthetic biology has largely been framed here as a biosecurity issue. It's all about biosecurity.

This is Europe. Biosecurity actually falls behind biosafety. There's a lot of discussion about the ethics and a lot of discussion about what we call business issues, the I.P. issues and who owns this. Much more balanced I think coverage.

And one can imagine a divergence even of public opinion and public policy between the two territories.

Now, in the end, science has very little impact on public perceptions. Culture does. The late novelist, David Foster Wallace, made the comment that "human beings are narrative animals". That's how we understand science. So the sphere of public concern usually forms around threats, rather than benefits.

This is one of my favorite set of comics in the 1950s, Captain Marvel and the Wonderful World of Mister Atom. The narrative there was the U.S. Government really isn't paying attention to atomic energy and it falls into the hands of various evil-doers. These are deep, deep narratives. And they are powerful because the science is essentially presented in the context of society and the people who do the oversight, the people who want to get at it for bad purposes, it's a story. We are story-tellers.

So we have gone back and we have sort of thought about the focus groups, there's a bunch of narratives that are incredibly powerful that come up again and again. I'll give you three of them:

"Dr. Strangelove," This is dual use 1, corruption of scientists. This was in "Spiderman 2." If you've got teenagers, they probably watched "Agent Cody Banks." If you've got gamers, there's an Xbox 360 game called "Bioshock." Very powerful and built into every single media. "The Trojan Horse," very, very powerful again. We accept these technologies into society and we learn later that it's probably a mistake. DDT, CFC, Thalidomide, Vioxx, this is a game called Nano Breaker,

same thing.
The last one is "Oops!" The accidental release of harmful substances due to human and/or technological error. Michael Crichton's wonderful book "Prey," the release of nanobots from a military laboratory in the desert. And the new movie, "Splice" where genetic engineers have kind of crossed an ethical boundary and combined human and animal DNA.
So the thing that the scientists have to understand is people will fall back on these narratives long before they will ever pick up a biology book. And they are incredibly pervasive, ubiquitous and powerful.

So, let me close up with some communication challenges. What is it? What is synthetic biology? We actually have 11 or 12 definitions on our website so I think five or six is an underestimate. Let me just make the comment, that the scientists, industry, or government have no communication strategy about this at all. We are mumbling in real-time. Okay, so it's wrong, quite often, to blame the media. The media has problems. But the scientific community has enormous problems in being able to communicate what this is.

Conversely, we haven't told them what it isn't. We had a discussion yesterday about whether this was cloning and we never reached a conclusion. So it's kind of open space for people's imaginations to operate in. And they will operate.

The other thing, is this a big deal? Who knows? I mean if you look at the responses to Venter's research you go from Freeman Dyson, who thinks it's a turning point in the history of humanity, to David Baltimore who says Craig has overplayed this. Is this a big deal? Do we have any way of knowing? How would we communicate that? How does this impact individuals and society?

I think we went through that a lot yesterday. Jim Thomas awakened us a little bit to the larger impacts we have to think about. Let me just tell you that people-- people always impress me. In the social context in which the public thinks is much broader than the social context in which most scientists think. They are going to ask very hard questions about who is developing this, who is promoting this, who wins, who loses and what can go wrong. Those are nagging questions for which we have, quite often, no answers.

I'm always impressed about how intelligent people are about this. What can go wrong? They constantly ask this, what can go wrong? And if something goes wrong, who's in charge? Where is the 800 number? Who do I call? Is it the White House? Is it F.D.A? Is it E.P.A.?

And the other question that I think is coming up now because of what's going on in the Gulf of Mexico is, can we fix it? "Can you plug the hole, daddy?" As Obama's daughter has been asking. So is there a biological blowout preventer? We heard a lot of stuff about suicide genes and phenotypical handicapping. Can you do this and guarantee that it's not going to fail? And the public will ask questions like that. I think we need to be prepared with answers.

So, just some final thoughts: I think it makes sense, potentially, to launch a bigger national dialogue on synthetic biology. This is the one that the U.K. just did, which ran for eight or nine months. We might be able to build off of the lessons that they learned.

I think there's a need to actually set up a very visible coordinating office and body in the U.S. Government. With nanotechnology, we had something called the National Nanotech Coordinating Office, which did a lot of out-reach and in-reach. And so there's a place to go to.

It's not clear kind of where you go here. This is going to happen soon. I predict in one year, someone in the Congress will ask the General Accountability Office to examine the adequacy of our regulatory system to address synthetic biology. And they should. The GAO would provide an independent assessment. They have the capacity to do that. They have moved into technology assessment. And I think we need to do this sooner rather than later. This was preempted because somebody actually suggested this, to have the National Academy of Sciences undertake a new study of environmental impacts.

The last time the Academy looked at bio-containment was in 2004. The chapter on synthetic organisms is relatively weak because they were very focused on animals, transgenic animals and plants. So it's time to take a hard look at this.

And I also think that people have to start looking at potential for extremely low probability but high-impact events. At the beginning of the nuclear age, Herman Kahn at the Rand Corporation used to say we need to "think the unthinkable". We need to look at what people call Black Swans, things that really could be game-changers that we're not thinking about.

And finally, I think it's time to really engage in greater international collaboration, not just around biosecurity, I think a lot of that is happening, but around issues like risk research, intellectual property issues, and the one that's kind of coming up again and again as we talk is the biosafety issues. So that's my comments. All of the things that I have referred to are up on our website. The work we do is funded by the Sloan Foundation.

Jim Wagner:
David, thank you very, very much. Let's move right along. We'll get to Q and A later.

Our next speaker is Markus Schmidt. Dr. Schmidt is the co-founder and board member and project leader at the Organisation for International Dialogue and Conflict Management in Austria. Dr. Schmidt has conducted several European Commission research projects on ethical aspects of synthetic biology and we certainly welcome you, and look forward to hearing from you.

Markus Schmidt:
Thank you. First of all, I would like to thank the Commission for inviting me. It's an honor to be here. I think it shows the commitment of the Commission to have this biological discussion and on synthetic biology drawn on the international level. In light of this, I will not try to hide my lovely Austrian accent throughout the presentation.

You have asked me to give an introduction and overview about what's going on in Europe in terms of social and ethical aspects of synthetic biology. I have 15 minutes for that and I will try my best to do this.

As an overview, first of all, I will try to give you an idea of what we think falls under the umbrella term of synthetic biology, rather than to give a definition to just see what's going on and who is doing what.

And it's a little bit about the role of Europe, compared to U.S., a little bit about the funding, what the European ethics councils are doing, what they've found, what kind of recommendations they are giving, and give some examples of ELSI projects in Europe.

We have heard something about maybe a different definition than what is included in synthetic biology and what it's not , for example, cloning or stem cells. So it took me quite a long time. I'm working in synthetic biology for five years now. And it took me a little bit in order to grasp that.

I think we can make out five different sub-fields or under the umbrella of synthetic biology. The first one is DNA synthesis or synthetic genomics. It is the reason why this committee has been put in place by Barack Obama and what Craig Venter is doing. I think you can maybe call that synthetic genomes the Guttenberg of biology. And maybe the step ahead, you can say that if synthetic genomics can create life, it's as pertinent a question to ask if Guttenberg has created the Bible. So it's about printing, right, but Guttenberg was not a Shakespeare or Voltaire.

So this is an attempt by the second group category which is DNA-based biocircuits and the creation of a biological system made of parts of genes. And we have heard we still have limitations in doing so, but it is going on.

The third group is working on the minimal genome to reduce the genome in a living cell to the extent it can barely survive to know about the least complex living systems, and to be used as a chassis for the second type.

The first three types are actually, you can say this is life as we know it, right? So they are using more or less similar principles of natural organisms. The second—the next two parts are actually descriptions and attempts to make life as we don't know it.

Protocells: researchers are trying to make cells from scratch, from basic, inanimate chemicals and putting together in a way so that one point in the future this will have all the characteristics of life. I think this would be the category where you can say they are trying to make

real, synthetic life, synthetic cells.

The last part is chemical synthetic biology. There are attempts to diversify the biochemistry of life. For example, to have a DNA with six, eight or twelve bases, instead of just four. Or to replace deoxyribose in the DNA and put in other chemicals like through ROs and have TNA and these things would be orthogonal — very different from natural organisms and we could have a kind of genetic enclave for biological firewall as a safety system. All right.

Comparing Europe to the U.S., there are many ways to do that. I went to the PubMed website and found it as well. The U.S. is ahead in terms of publications and also in terms of receiving funding for the work, but Europe is second to the United States. So I think together we might have 80% or 90% of the synthetic biology volume capacity in the world.

But Europe is very diverse. There is, on the one hand, European Commission funding initiative, but on the other hand there are also national initiatives, but there are different. In some countries there is a good research community but they are lacking funding, like in France. In Austria we have a good ELSI community but there are hardly any scientists working on that. The best case, the benchmark in Europe is certainly the U.K.. We have communities of synthetic biologies that have funding. Same is true for ELSI research community. And they even required to work together and to collaborate so they set a good example for Europe. So all these publications, work and funding in Europe on synthetic biology have drawn to the attention the fact that there might be biological issues and there have been a couple of bioethics communities in Europe working on this. Or, not working on this.

So the first example here is the U.K., where the Nuffield Council of Bioethics has repeatedly decided not to work on synthetic biology in 2006, 2007 and 2008, because they thought it was not relevant ,but in contrast to that, many other countries have. For example, in Germany there were different ethics councils and, for example, the Ethics Council of the German Parliament and the German Ethics Council. Which, if you have seen the “Life of Brian” by Monty Python, reminds me of Judean People’s Front versus the People’s Front of Judea.

Not quite clear.

[AUDIENCE LAUGHTER]

At first, the German Ethics Council said it was not relevant and they didn't want to work in that but the Ethics Council of the German Parliament said, well, it might be relevant. And now I think the German Ethics Council is doing something in it as well. Switzerland, actually a very interesting publication recently coming out. The Federal Ethics Committee on Non-Human Biotechnology; it's an awful long word in German. They look especially on the nonphysical harm part of synthetic biology, so the ontological ethics, the dignity of microbes. We're looking at microbes and if we can treat these microbes as machines or if they have a special category and they entertain different positions, like biocentric position, theo-centric, eco-centric, and so on. And so they came to the conclusion that the majority of people in this committee entertain a hierarchic, biocentric view. They say that, well, microbes are not machines, they are alive and have a dignity, but this dignity is much less or not that important as other, higher animals and organisms and they we can use them in any way we want.

Actually, it's a green light for scientists and we're very happy to have heard of these scientists. Nothing to add to that. Also in the Netherlands, there was the cochairman made a statement, but I would like to say a little bit about the European Commission itself.

In 2008, President Barroso asked his bioethics committee, the European Group on Ethics in Science and New Technologies, to also have an organized recommendations or to come up with an opinion paper which they did and published in November last year. We are interested and they asked "what is our one recommendation to you", it could that you might want to look at their recommendations and see if there is something useable.

As I mentioned before, biosafety is really an important topic in Europe. Much more than biosecurity. I think that is one major difference between the U.S. and Europe. There are several points in biosafety, especially we need to develop risk-assessment methods so that we can, in the future, try to assess the risks of new synthetic biology tools and methods, otherwise it would run into a situation with just

uncertainties. They also entertained the idea of labeling products that come out of synthetic biology; they don't want to do it, it's just an idea that they could do. Include the biosafety standard when doing import/export with synthetic biology products.

And promote public debate, and also that it's necessary to support public support for basic research and ELSI work. Here I've got a timeline of different projects dealing with societal and ethical aspects in Europe. The color code doesn't have any meaning, it's just more colorful. Some of the projects are stand-alone ELSI projects, and others are science projects where they have an ELSI part. Some of them deal with — Okay.

So in order to map the different projects in this real world, you know that Europe has a history of colonizing and we do that and have this virtual world here. Five different areas of synthetic biology and different ELSI aspects, okay. Also try to map the different projects into this virtual world. You see that most of the activities are going on in biosafety and ethics and most of them regarding DNA-based biocircuits and those are initiatives and DNA synthesis, ISP initiative, and there are some activities on science and society.

And, socioeconomics. I'd like to, in my last couple of slides, present some of these projects I know best and have been part of. The first one is SYNBIOSAFE, which was the first European project on safety and ethical issues in synthetic biology. It was, in a way, a pilot study to map fields and see if there's anything new in safety and ethics. And what we did in our ethical part, we found out that the ethical aspects that may come up in synthetic biology, can be attributed to three different areas, whether it's about its applications, that would be like human enhancement. Now, for example, there is-- we can do synthetic, human chromosomes that can be used for gene therapy that would be an issue. Or related to its distribution, is what we heard yesterday with the bioeconomy and what is the effect of synthetic biology on the global justice, and the distribution and benefit in order the procedure of such is the ontological status of living machines.

Regarding biosafety, we have three questions or challenges. The first one is we need to find new methods in risk-assessment in order to make sure we can have some certainty about the risks of new products

in synthetic biology. And second is, what are the ways to improve synthetic biology, to improve the biosafety by using tools of synthetic biology. For example, I mentioned before the different DNA with different chemicals. We would have a nocturnal system or different forms of auxotrophy feed where we feed them things that don't occur in nature and so on and so forth. The third one, the third point is about what happens if nonprofessionals, amateurs and do-it-yourself people, start using that.

In addition to some publications, and a book we just wrote, we also thought it was necessary to produce some material for the general public so they would get more and more people interested and motivated to enter the discussion. We did this documentary film; I brought two copies for the commission here. You can get more information on this website (www.synbiosafe.eu).

Starting from this more general assessment of risk and benefits, another project here, TARPOL, which is the abbreviation for: Targeting environmental pollution with engineered microbial systems a la carte, is from the European Commission Seventh Framework Programme. We're looking into specific applications where synthetic biology could make contribution, and try to find out what its economic, environmental, and social impact would be. Okay? So this is going to be published in September. So this is a draft. If you want, I can send you the final version.

So we have, for example, in biofuels we're looking to ethanol, non-ethanol, like butanol kind of fuels. Algae-based fuels, biohydrogen, and microbial fuel cells and try to evaluate the different aspects. This is a way to go away from the general assessment to a more case-by-case assessment.

Another project that we have done in Austria is COSY: Communicating Synthetic Biology, where we wanted to know more about public perception. This is in the light of a certain lack of knowledge about synthetic biology. Although we do have, in the last couple of years, more and more press articles, in this case in the German language media but is very similar in other countries in Europe. But there are certainly most of the people haven't heard about this German, but it's very similar in the United States. And it can give you another hint in

next September, the new Europe study is going to be released. And this is every three years the European Commission is doing a massive poll, opinion poll in Europe asking a total of 30,000 people in Europe on different aspects of biotechnology. And for the first time, we were able to slip in some questions on synthetic biology. And it's going to be-- I have seen the results but I can't tell you yet because it's published in September, it's going to be out there. It's going to be useful for you.

Doing this and this lack of knowledge and awareness, we're doing a real-time experiment, asking scientists to write press releases, asking real journalists to write articles and give that to eight focus groups consisting of different parts of the public. And what we found is that — these are the eight groups, right? And the scale is if the people would be rather positive link lined or negatively or neutral. In the beginning because they didn't know anything, they are more or less neutral and don't have any opinion on synthetic biology. Actually, the name should be here as well. And it turns out that after they received the articles, we see that like the majority, like half of the groups that didn't change their opinion, they still didn't feel — seem to engulf them a lot, but two groups had the suddenly very negative opinion and two groups suddenly get a quite positive opinion on this. So this group on the left was an environmental NGO and this group was a Christian NGO and here we got students and these are members from the economic chambers.

It turns out synthetic biology has the potential to polarize parts of the public while we have a silent mass of people that don't care a lot. But, of course, there are people on the fringe of interesting. We also found that in this communication process from science to media to the public, actually the very essence of synthetic biology got lost. So while, at the beginning, the scientists were talking about why it was different from genetic engineering and they had the standardization and the engineering principles, this got lost. And in favor of a more application-focused kind of information that was conveyed. And this is important from the point of view of journalists because they want to write something that is relevant for people and it's about applications.

So because they just talk about applications and about the method

behind it, people cannot make a difference between synthetic biology, genetic engineering, or bioculture, so they put it all together. And the research from this communication process, the nuances get totally lost.

This is my last slide. We heard yesterday that if synthetic biology is successful, imagination will be the limit. If this is really the case, I think we should invite people that are experts in imagination and maybe not only engineers. And so we are inviting filmmakers and artists to give us their version of what synthetic biology could—how it could change our society in the future and we are going to do a science, art, and film festival at the Museum of Natural History next year in Vienna and we're still inviting people to send us short films. I think it's going to be a very interesting festival. With that, I'd like to thank the Commission for your time.

Jim Wagner:
Thank you, Dr. Schmidt. Very interesting to see the sort of European response to the challenge for public dialogue that David Rejeski issued to us. Our final speaker in this morning's panel, I have a special pleasure to introduce, it's Dr. Paul Root Wolpe. He is the Asa Griggs Candler Professor of Bioethics and Director of the Center for Ethics at Emory. And Dr. Wolpe sits on the editorial board of more than a dozen professional journals, is the past president of the American Society for Bioethics and Humanities. His work focuses primarily on the social, religious and ideological impact of biotechnology on the human condition. I am delighted to welcome you here, Paul. And we look forward to what you have to say.

Paul Root Wolpe:
Well, thanks very much. It's a great pleasure for me to be here. I'm a sociologist and social scientist, and very atypically for me I will not be using slides. We'll see if I can-- you know how some people can't talk without their hands? We'll see if I can actually talk without a PowerPoint presentation.

I was very pleased with the breadth of ethical concerns that were expressed yesterday because it freed me up to talk about what I think are some less-often considered and in some ways, perhaps, underlying and deeper ethical concerns that I have. Concerns that are as trou-

bling in some ways as ecological or pathogenic concerns, but much more difficult, I think, to know how to address.

My assignment today, what I was asked to do, was talk about religious perspectives on synbio. And I spent a few weeks reading the literature. I spoke to people from a variety of faith traditions, from Buddhism with Emory's wonderful Emory Tibet program that we have; people from Islam, Christianity and Judaism, Hinduism. And what I discovered was there was remarkable agreement about synbio. And that is at this point, they are unconcerned. That fundamentally, their objections or their concerns were those of all of us in this room. What are the potential harms? What might happen if these things are released into the environment? And they expressed a concern that synbio keep its eye on maximizing human good and reducing suffering. And if it does that, it's acceptable. And that was reflected, I think, in the Vatican's response, for example, to synbio where they said that the recent creation of Venter's cell can be a positive development if correctly used. And then there was a warning afterwards, but scientists should be careful about playing God, creating life, remembering that only God can do that.

I find the questions that we typically ask of religious traditions about bioethical issues to be relatively uninteresting. We focus too much on asking for their imprimatur, for them to sanction what science is doing, but I don't really think that's the right question we should be asking of religious traditions. It's not where they can make their greatest contributions in telling us what we should or should not do. Rather, I think that modern science is simply the newest means of trying to struggle with eternal questions about how to minimize human suffering, what our proper relationship is to the natural world, what are the important problems we as a species must solve, and so on.

Religious traditions have had centuries to think about these questions. And the smartest people of their age throughout most of human history drifted into religious dialogue. And so those traditions hold fonts of wisdom that we can draw from.

We know that the role of science is generating knowledge. What I think is most valuable role of religious traditions, what I think we should ask of them is how to generate wisdom, which is a different

quality than knowledge alone. And so for a few minutes, I want to talk about what kind of wisdom we might glean about synbio and similar biotechnologies.

These aren't going to be the points that are usually made explicitly by religious traditions or religious spokesmen, nor do they come from particular religious traditions. They come, rather, from what I think of as kind of a generalized religious sensibility, a posture that asks what our positions might be if we start from the premise that there's something sacred about our lives even if you define the word "sacred" in its most secular sense. Religious sensibility that I mean is shared by a variety of people of faith and by people of no particular religious faith, by both the theist and agnostic and atheist. It begins with the premise that life is rare and precious, that our biosphere is fragile and singular and of inestimable value, and that we have evolved to be the stewards of the planet, and very powerful stewards at that.

One last point before I move on to the specific points I want to make, I don't think wisdom is at all an exclusive domain of religion. We find it in art. We find it in literature. And we find it in science, as well. In fact, if you look at science's impact on religion over the last 100 years or more, we see as profound an impact going in that direction as we do in religion's influence on science. So I'm interested in that dialogue between science and religion to some degree and how they can mutually inform each other, and that is a dialogue of longer duration and greater productivity than is generally appreciated.

So I want to give four examples of what I think of as some ethical issues that are difficult and perhaps even retractable, but might reflect this generalized sense that I'm referring to.

First is the idea that human beings are co-created by technology. We think of ourselves as the creators of technology, which we then somehow send into the world and then we create the next technology and send it into the world. We pay far less attention to the ways that the technologies we create then reciprocally recreate us, recreate human beings and recreate human society. The invention of the plow shaped human societies for millennium; modern civilization itself was largely a product of plow-based agriculture. The automobile made suburban life possible, moved industry out of the cities, and even perhaps

ended the era when people had to keep animals for transportation and thus estranged us from the natural world even more. Computers, we don't even need to mention how computers have fundamentally changed us, not just the socioeconomic and synthetic biology results of computer power, but even parents being unable these days to figure out how to communicate with their own children. We have a whole different system of communication than many parents do.

Yesterday we heard some speculations of how synbio might contribute to bioeconomic dislocation. Powerful technologies can change social relationships. Change how we think about problems. New technologies create new problems that call for even newer technologies to solve them, which then create their own challenges which we address with even newer technologies which is why we always seem to have both too much technology and not enough technology at the same time. So how will synbio change us? I have no idea. I don't think anybody does. Perhaps it will accelerate the biomedicalization of life whereby diverse human phenomena are recast and redefined primarily by their biomedical nature. Perhaps it will change our personal self-conception from one that thought of individuality as a variation on our commonality, to one emphasizing our polymorphic divergences and idiosyncrasies. Perhaps it will be the final step in the commodification of living things whereby all biological forms will be thought of primarily in terms of their utility. I don't know. It's too early to tell and premature probably for the Commission to speculate on. But I think we all agree that looking at technology in isolation from the economic, social, philosophical, and political implications of its future development, is to fail to fulfill the deepest meaning of the President's charge to explore the implications of the field.

The second issue is speed. And this is a point that I think is often overlooked in talking about technological change. Speed itself is an ethical issue. We live in a society that explicitly and implicitly presents speed as an ethical value. Taking longer time to achieve similar results is seen as less desirable, as wasting time; doing something faster is doing it better. Synthetic biology and genetic engineering, as well, justify the utility, in part, as we heard yesterday on how they have dramatically collapsed the time horizon of evolutionary change--as Drew Endy has pointed out. Yet, speed is a problematic value. Selective breeding, for example, is limited, difficult, and time consuming.

And so in that sense, genetic technologies are an improvement. But because it plays out over long periods of time, it allows for reflection and self-correction. Change happens slowly which offers a large range of choices at each new increment of intervention. Synbio collapses that whole, long process into a single step. Yet, it may take many generations to understand the impact of even the single gene change on the integrity of an organism as a whole. It may take many generations to appreciate harmful impacts genetic alterations may have on human consumption or on the environment. Even sysgenic transfers may have consequences that differ from selective breeding.

So speed has an impact on our deliberations in two senses. One, in the ways that synbio speeds up natural processes. And second, in the explosive development, routinization, and dissemination of synthetic biology, technologies and methodologies themselves. How do we think about, accommodate, and understand the ethical implications of speed?

The third is incrementalism. It's a difficult dilemma. We can follow a path where every step is examined individually and found to be ethically unobjectionable and yet, 100 steps later, we found ourselves in a place that no one wants to be. The idea is also captured by the fact that most synbio research findings advance our knowledge incrementally, and yet somehow we see the enterprise as a whole as transformative. One of the reasons for behavior-based religious systems like Halakhah in Judaism, or Sharia in Islam, or for the Vinaya discipline of monastic Buddhism is exactly to guard against incrementalism and it is what is seen in these religious traditions as kind of pernicious potential to drift slowly away from what each tradition sees as right paths. I think, in fact, it is actually a kind of incrementalism that people are trying to combat when they resist biotechnical change or resist an enterprise like synbio or nanotechnology. Perhaps it's even really what underlies the playing-God objection to some degree. And so when we respond that we've been playing God since homo habilis first produced stone tools, I'm not really sure that that addresses the incrementalist's question that underlies it.

Yes, we have been playing God along the way, but is there some point in which our changes to our natural environment, our changes to our physiological integrity, our changes to our fellow creatures has crossed

some line though the line is obscured by the fact that this step really isn't that much advanced from the step before us? It presents a real policy challenge. How do I say that step "A" is okay and "B" is okay and "C" is okay, but "D" isn't okay when "D" is really indistinguishable in many ways from "C" and the real reason I want to stop at "D" is because I see "H" down the line? How do you create a policy that captures the subtlety of incrementalism? It's very, very difficult and perhaps the best way is to address in a positive way by creating goals and incentives, rather than trying to stop things.

And the fourth point is what I call the fetishization of progress. And this is something that is often expressed by religious traditions. A fetish is defined as: "any object, idea, et cetera, eliciting unquestioning reverence, respect or devotion." Got that right out of the dictionary. I submit that that description captures the general cultural posture of many people and most scientists towards scientific progress. Here religions have a lot to say.

A report of the executive committee of the European Ecumenical Commission for Church and Society wrote, "Our Christian heritage teaches us to be skeptical of romantic notions of unrestrained human improvement in scientific progress that prevail in some parts of the scientific and political communities. Our support for scientific research is moderated by our awareness of human finiteness and fallibility."

Scientific progress is, itself, a secular faith. Modern biotechnological science has a history of failed prediction and hyperbole from predictions of gene therapy that I was very involved in early in my career, to the claims early on that nanotechnology is going to solve hunger and our energy problems and everything-- and virtually everything else. While the cautions of some temperance in our scientific zeal are easy to dismiss, there's wisdom in pausing periodically to question scientific utopianism, the argument of urgency and other underlying assumptions of some biotechnical advocacy.

Perhaps here it might be instructive to conclude, as both the previous speakers alluded to, by drawing from two narrative traditions, or two narrative tales, one coming from secular Christian tradition and the other from my own Jewish tradition. There are two tales in addition

to Dr. Strangelove and Oops! and the other things that they were saying, that I think have become very much paradigmatic in this area.

The first is the tale of Frankenstein. The Frankenstein tale is a product of a Christian cultural view that had underpinnings of suspicion and worry about technology. In fact-- By the way, what isn't usually commented on, is this whole idea of playing God is a very Christian idea. It doesn't exist in Judaism, Hinduism, Islam, or Buddhism. All of which are much, much more historically predisposed to science than certain strains of Christianity. Though, that's not true, of course, of all strains of Christianity. The story of Frankenstein is a scientific one. Anyone with the right technological knowledge can manipulate life and create it. Some of you may remember Mel Brooks', "Young Frankenstein", where Gene Wilder breaks into his grandfather's laboratory and there's a book called "How I Did It". So you just have to follow the formula and you can do it too. To Shelley, the creation of human life is clearly improper. Dr. Frankenstein transgresses and Christianity and European thought condemn him. Frankenstein is a monster, is a freak.

The story of the golem is quite different. The golem is created by a great Rabbi Judah Loew ben Bezalel, to safeguard his people. He is not condemned for creating the golem, nor is it prohibited. If fact, the Talmud accepts the creation of life and there are many stories of rabbis creating goats and life-- goats and human beings and other forms of life. And Loew considered the golem an extension of the natural part of co-creation of God. Unlike Frankenstein, by the way, who was created by putting together biological parts, the golem is a synbio creation. Rabbi Loew brings it to life by writing three letters of a religious genetic code on his forehead and then he's alive.

But there are two differences in the last second between these stories that I want to leave us with. Victor Frankenstein is portrayed by Shelley as a driven man, arrogant, who displays a number of examples of personal cowardice in his story. His temper is violent, his passions strong. When the monster disappears from his house, he's relieved and then he flees instead of taking responsibility. In contrast, only the most righteous can create a golem, can manipulate life, and the degree of technological success is correlated with their degree of righteousness.

By breathing life into the clay, Rabbi Loew emulates God and so sees as his responsibility to emulate other Godly qualities. And if we look at that biotechnology and biological science research council report that was put in the packet, you will see that one of the biggest concerns among the public was the motivation and disposition of scientists making the research, whether they could afford dignity and responsibility and respect when intervening in the natural world. And finally, the second and last point I want to make about these two stories is Dr. Frankenstein loses control of his namesake. There is no safety mechanism built into the monster. And ultimately Frankenstein must pursue his creation and he dies trying, unsuccessfully, to end the monster's life. While the golem always remains under control of its creator.

Rabbi Loew builds a safety valve into the golem and when he gets out of control, he simply has to remove one letter from its forehead and it turns back into clay. And it's heartening to see the leaders of synbio have taken that idea of the safety valve seriously and built it into their products. To the Commission, I have tried to highlight three or four what I think of as very difficult issues. And I think the challenge to the Commission, as it seems to me, is to take the extraordinary knowledge presented us by synbio and temper it with wisdom.

Thank you.

Q & A

Jim Wagner:
Thank you, Paul. Appreciate it. I do want to defer first to our chair but we have questions from the Commission.

Amy Gutmann:
I'll wait for my question and go straight to the Commission and ask mine later.

John Arras:
Well thank you all very much. Paul, first I want to reassure you that it's perfectly okay not to use PowerPoint. I believe that PowerPoint is the spawn of Satan.

[AUDIENCE LAUGHTER]

I actually applaud you for not using it.

Amy Gutmann:
The Commission will not take a position on the use of PowerPoint.

[AUDIENCE LAUGHTER]

John Arras:
But I'll be working on you all. So I want to begin with this reflection on the absence of trust with regard to these sorts of scientific developments. I think that Dr. Rejeski is correct that this is the social environment in which we are working here. It's an environment marked by an absence of trust. And we see this all around us with regard to BP, with regard to climate gate, and so on, where there's just a high degree of suspicion with regard to all of our major institutions. The church, science, business, government, everything. So in this kind of environment, I think you're right that some kind of public outreach, public engagement will be absolutely crucial. And I have read your excellent article, David, in the reader which does talk about the importance of engagement with the public. But I think we need to probe that a little bit deeper to get at the rationale for doing so.

I mean one rationale could simply be to sort of work on the public, you know, to sort of massage the public or tweak the public in various ways in order to make the world safe for scientific development. Another way of thinking about it, which I think is much more plausible and philosophically appropriate, is to view public engagement as a way to obtain public legitimacy. In other words, if the public sees itself as having a role in the formulation of public policy, that bestows a certain amount of legitimacy on the project. I think we can see this. We have anecdotes so far. We have anecdotes. We have a couple of case studies in this. One of my favorites is the rationing program in the state of Oregon, where public officials in Oregon basically reached out to the public, engaged them in a prolonged discussion. And it turns out that in the state of Oregon, people can — the state can ration healthcare in a rational transparent and effective way that gained public acceptance.

So I'm wondering what you think about the prospects of this kind of public engagement in the area of synthetic biology. Is there any evidence that this kind of engagement will, indeed, engender and increase legitimacy? Or is it just a kind of theoretical notion that, you know, involves a lot of hand waving?

David Rejeski:
I think there's always a certain amount of skepticism and fear of doing this. I think the scientific community has often used as a deficiency model which is, the public simply doesn't get it. And if they only got the science, they'd get on board. And part of the problem is, of course, this public is asking a different set of questions. I think one of the problems that you run into immediately, is if you wait too long, it appears disingenuous. This happened to a large public engagement process in the U.K. called GMO Nation where it really started after — essentially, it looked to the public like the train had left the station.

John Arras:
GMO Nation is like their worst fear.

[AUDIENCE LAUGHTER]

David Rejeski:
Right. And recently the French conducted a large national engagement process on nanotech and it was actually shut down in a number of sites by protests, again because people felt nanotech products are on the market and we have essentially done this before.

So I think part of it is there's a timing issue. And so I think if you really are serious about this, it has to be done fairly soon. The report we just put out on participatory technology assessment says there are ways of doing this that are extremely well-tested. We have done 16 of these types of exercises in the U.S. alone. And they are used pretty widely in Europe. This is just a matter of getting a representative sample.

One of the things you'll grapple with, and I'm sure you'll be asked is, are the people you're talking to representative? That's a statistical

question and methodical question you'll have to deal with. So I think there was an interesting process that was run on biomonitoring in Boston. This was done a few years ago and brought in a wide range of people from the public, a fairly representative sample to talk about monitoring. And it was visited at the same time by the head of the national academy panel that was doing essentially an investigation on biomonitoring for the U.S. Government. His response was, he was stunned at sort of the level of conversation by an informed public because you actually have to inform the people what's going on. And the fact that they actually came up with new ideas.

I think it goes beyond legitimacy. I think people can generate new ideas, new ideas for policy, things you hadn't thought about. So I think it's not just sort of educating, it's not just sort of dumping knowledge, it's not just trying to get some legitimacy by having a dialogue. It's also the fact that people are smart. They get this stuff. And that's why when we have done our public focus groups, we float a lot of public policy ideas. People come back and we say, what do you think about labeling? What do you think about a moratorium? What should the F.D.A. do? What can they do to build your trust? For me, I come from a policy world. So I think the use of these as ways of informing public policy is actually very, very critical. So I would push you to actually go beyond the legitimacy issue and just having the dialogue and just sort of say, how can I learn something from millions of people, at least a representative sample of those?

Nita Farahany:
I have two questions. First, I want to thank Mr. Rejeski for your specific recommendations. I thought they were incredibly helpful and your study I think is really quite enlightening for us, as well. My questions are actually directed to Dr. Wolpe.

The first one, I was quite surprised when you said there was no religious perspective, or difference at least, within the religious community. And I wonder if that was a representative population that you spoke to, because I would suspect there may be some differences, particularly around the questions of life, dualistic versus materialistic concerns about the creation of life. And so I wonder if the question of awareness, of the degree to which synthetic biology is being included under the sort of large umbrella, and whether or not you think that

there may be concerns develop.

Let me ask you the second question. Your answer to incrementalism and to the rate of change was that we should create goals and incentives to keep in mind as a way to direct this. And I wonder if you have specific ideas as to what those goals and incentives are and if they would address the shifting rate of change in the environment.

Paul Wolpe:
Thank you. I wasn't trying to say there aren't religious objections to synthetic biology. There are some religious groups that object to virtually the entire modern scientific enterprise. I spoke to mostly official or high-place spokesmen for religion and these religious traditions asking them what their religious traditions say specifically about this particular case of the creation of the artificial cell. What I got in response from almost all of them was, at this point, the actual act of creating a synthetic genome and inserting into a cell that replicates is not one that we have any particular ideological or theological objection to. I asked a very narrow question.

Nita Farahany:
It was not about synthetic biology generally or their views about it.

Paul Wolpe:
Right. And so far as the conversation as it went on as it invariably did as to where their problems lie, they tended to all be down the road or they tended to be in this more intrinsic issue of hubris or of proper limits of human intervention or of humility or issues like that. And I think part of the reason for that is that synthetic biology is nascent enterprise and, like us, nobody really knows all the implications of it are, and so there's a "let's wait-and-see" attitude.

But religious traditions, especially outside Christian religious traditions, tend to see the use of other forms of life to better human life as a legitimate enterprise within certain limits. So creation of synthetic biology products that would cure disease or help with things like mitigating pollution are seen as legitimate scientific goals.

The issue of incrementalism, the reason that I'm suggesting positive incentives rather than regulatory limits is because nobody knows and

I certainly don't know where to put regulatory limits. And as I say, it always seems arbitrary. Therefore, in some sense, it is a very practical difficulty that leads me to suggest that positive incentives are a better policy strategy.

At this point, I think it's premature to suggest where the proper goals of synthetic biology are. That needs a little bit more time. But it is exactly what we do in medicine, of course. So we create the NIH. And the NIH looks at-- it is the steward of public funds. It looks at all the possible places that it could invest public funds. And it makes value decisions about what kinds of medical products, goals, cures, preventions are in the best public interest and then it incentivizes the system to try to move in those directions. That's what NSF, of course that's what all of our public funding agencies and private funding agencies do.

So I was just suggesting that it's such an intractable problem, the problem of incrementalism, that that is a better strategy, even though I don't really have a specific recommendation at this point about what specific goals that incentive program should pursue.

Nita Farahany:
Thank you.

Michael Nelson:
I'd like to ask Dr. Rejeski to, perhaps, be a little more granular in your thoughts about how you would organize the lack of a communication plan, certainly in this country, compared to Dr. Schmidt's presentation which is fairly I think stark support for that comment.

How would you suggest, based on your comments of yesterday, that you wanted more government agencies to be in the room and to be part of this process? And yet when you went through your five specific recommendations, you suggested a coordinating body or office within the U.S. Government.

Where in your view should that bully pulpit be? And what would you recommend for its composition outside of U.S. Government agencies? How would you interdigitate with the international approach that you did mention at the very end? But Dr. Schmidt showed with

great granularity. And, how would you bring in a community advisory process so that this would not be a deliberative process that would seem to be in the hands of just policy or technologically wonky people?

David Rejeski:
Well, the last thing is obviously the big danger. I think logically, it should be at a White House level. You know, it could be worked down at the national science and technology council. The national nanotech coordinating office was set up as an independent body that reported up through the White House and was funded essentially by the different agencies. I think that is one model.

I think they were consistently underfunded so you have to figure out a way of kind of levying a certain tax on the agencies to make sure there was enough money there. So one of the tasks that office was given was to actually have a national dialogue on nanotechnology. And that never really happened. There really wasn't enough money, enough umph there.

So I think, if you did it, you have to come up with some way of making sure that there's enough funding going into the coordinating function. The agencies have to be able to pony-up some money to make that happen. In terms of advisory bodies, you know you're going to run into FACA issues in terms of the federal advisory act. But it may be worth going through the process to actually set up a FACA that would bring in the wide swath of population and communities to be able to sort of get ideas off of.

The other option, there's nothing that would stop government and the agencies from going on the road. When I was in the White House, we did work on the national environmental technology strategy and we had 25 meetings around the country. They were just the kind of thing you're doing, but again they were focused on a specific technology and science area. We ended up also with a White House conference which is another thing that attracted 1400 people. So we were constantly bouncing ideas off, ideas that had been taken from the government and getting lots of different feedback. I would say that one of the things that came out of that was exponential improvement in our strategies because we were able to really interact with

stakeholders.

So I think there's a bunch of different ways. The level matters. It has to have White House support; that's where it belongs. If you have a coordinating body, you have to have enough essentially enough money behind it to make it work. There has to be some leadership there. I would certainly recommend the use of potentially putting FACA in place. It might help.

Daniel Sulmasy:
Thanks again. I think we were treated to three very different, but very, very good presentations. My question would be for Dr. Wolpe. Paul, you probably know there are sort of two ways we can think about religious voices participating in public dialogues like the one this commission is conducting. One strategy is to sort of only give publicly accessible reasons. And the second is to allow people of religious communities to speak out of the fullness of their traditions. You seem to have allowed a broader sense of the second kind of participation in a dialogue like this. And I was wondering what you think the actual — if that's true, what the actual value is of allowing people to speak out of the thickness of their own traditions as part of a public debate about a contentious issue like this one.

Paul Wolpe:
I think the problem with religious perspectives in a society that's supposed to have a religion-state split is that religious traditions don't get to talk about why they really believe what they believe. If you get up in front of Congress or a commission and you say I think this is wrong because the Koran tells me it's wrong or the Torah or whatever your sacred scriptures are, it's the end of the conversation, not the beginning of the conversation. You have to translate parochial religious ideas into universal principles if you want to be—if you want to be convincing about why you should take actions. But I think underlying the parochial reasons that religious traditions think things, are often very deep principles that can be universally expressed. And I think that in our society, that is the greatest contribution of religious traditions because these are well thought-out, centuries old, much debated, much-- very nuanced positions. So that's what I tried to do here, rather than reiterating what I think are very easily accessible and commonly discussed religious positions about technological issues. I

was trying to get underneath the surface and ask what is the font of concern from which religious objections spring?

Amy Gutmann:
Well, thank you all three. This has been enormously insightful and informative. I think it will help us moving forward. So I really like the idea, if you would mind my changing one word. Instead of knowledge tempered by wisdom, knowledge coupled with wisdom. And I think we, as a commission, would like to issue a report that is informed by the facts, knowledge, and driven by values, wisdom. To elevate it a bit. And I'd like to ask any of you to share — we can start, if you want, with Paul. What are the values that you see us having to deal with? What are the values that are most relevant to the issue of where synthetic biology is likely to go? The values that we need to deal with as a Presidential Commission. Just, I know this is a big question. But if you can give us one answer.

Paul Wolpe:
My answer would be that it isn't a single values question. It is a balancing of values problem. That is, when I talked about the fetishization of scientific progress, I wasn't trying to say I was against scientific progress. I am extraordinarily for it. I live my life in a medical environment and celebrate medical advances but there are other values, too, that have to be brought in. So I think your challenge is not so much what is the value we should represent in our report that will be the value that synthetic biology needs, but rather how do we create a report — and I think temperance might be the right word — that takes all of these competing values and balances them in a way that makes policy valuable.

Amy Gutmann:
I should say that why I asked about values, there was a famous philosopher who said that "values without facts are lame. Facts without values are blind." So we take both sides of this. You can speak to either one.

Markus Schmidt:
I would like to refer to this Swiss bioethics commission with which entertains different positions one could have and from that different values are entertained. There were, for example, thinking about

people that believe in the kind of monism-- that every organism can be explained or reduced to certain physical and chemical properties can be lost. And there are a lot of people that still have a legalistic point of view that doesn't know that there's something special in life. There is some X-factor that cannot be controlled or engineered. I think many in synthetic biology, they come from this monism concept and there's a little understanding for this vitalistic idea to think the two positions can get in the way, in a way that it's a direct attack, so to say, that there's some specialness of life. And this carries a lot of value. It is the position as unfounded as the other one, but it's a way we view life. And if we attack that, or if this is an attack by synthetic biology, it could trigger some strong reactions to that.

David Rejeski:
I would think that one of the things that would be very useful in the report was a sense of the sensitivity and celebration of plurality. We are a very plural heterogeneous society. One of the things that's so striking when we do focus groups is the huge difference. We talked about religion. There are huge differences between men and women. There are huge differences between whites and people of color and how they view this and the trust issues. And I think it would be phenomenal if the report could kind of reflect that.

We have a plural society and we have gone out and we have kind of looked at that. And we have probed deeply into all the little pockets of society. And I think that's something that is what gave rise to, quite often, resistance in the environmental justice movement for instance. So I think that's something that you have to do. There's going to be the sense of how deep have we gone. How sensitive have we been to the plurality of the society? We're in a different place, quite often, than a lot of the European societies. And you've got to deal with that. And I think it can be dealt with on the basis that links values with facts.

Stephen Hauser:
Thank you. And thanks to the panel. I might ask David Rejeski a question, but also open it to the other panelists. There are certainly unique capabilities of synthetic biology. But one of the issues we spoke about yesterday is the overlap in the issues that are raised between this new technology and other technologies, genetic engineer-

ing, stem cell biology, even nanotechnology. And my question is in terms of the public debate and also the oversight framework, are we better isolating synthetic biology? Or addressing these issues in the larger context of emerging biotechnologies?

David Rejeski:
Well, I'll give you my opinion. I think there actually is a certain danger in creating different-ologies. Twenty years ago, the U.S. Government made a—whether it was a conscious or unconscious decision, that our goal was to basically build another Industrial Revolution by gaining control of matter in a nano scale, in a biologically relevant scale. We started with nanotech and that was focused largely on inorganic matter and now moved to organic matter. This is all about precision control of matter. That's going to change the way we make everything for the next 100 years. This idea of separating things, one of the things that was striking when you saw some of the slides, it mentioned nanotechnology. And so there's people up at MIT that actually reengineered viruses to make batteries. So the nano folks, they have been talking 10 years about self-replicating nano. Biology does that and we're in the position to program it. And obviously Drew mentioned this ability to decouple bits from atoms and program the bits and address them back to the world of atoms. So I think the national science foundation has talked for years about converging technologies, the nano and info and bio world. And so I think there is some value in thinking about the fact these are all coming together now and asking the question about, well, how will the regulatory system work? And will the toxic substance control act work well with nanotech and nano biotech because they are all starting to get more complex. And you can do the same exercise through most of the U.S. statutes and most of the U.S. agencies. I think there's a tension there. Quite often it seems conceptually easier to break it down. But I don't think that's where we're going to end up in 20 years. You are already seeing a tremendous kind of convergence. And there's also lessons to be learned, as we have already talked about I think.

Jim Wagner:
Let me ask the audience if there is a question or two. Wow. A large number of questions. I'll tell you what. Why don't you collect your questions and then let them run through them? Give me your question and I'll note it down. Introduce yourself and then we'll turn our

panelists loose on you. Please.

Sarhath Josey:
My question was for Dr. Schmidt. And it was basically is there a need for international standard for synthetic biology? But biotechnology in general as well.

Amy Gutmann:
Introduce yourself, please.

Sarhath Josey:
I'm Sarhath Josey, a student at Dartmouth College.

Jim Wagner:
Welcome. Good to have you here.

Gerald Epstein:
I am Gerald Epstein, of the Center for Science, Technology and Security Policy, AAAS (American Association for the Advancement of Science). I guess this is for David Rejeski. I have a pocket hobby of collecting policy studies whose recommendations include the president needs to make this a personal mission. In terms of the U.S. office or U.S. Government wide office, maybe it's related to the last question we had from the panel. Is this technology so special that it really needs a special White House office? Or does that office need to pick a number and stand in line behind White House office for neuroscience, White House office for biomemetics? …

Jim Wagner:
And what would be the priority for that? Yeah.

Gerald Epstein:
Do we need lots of them, or is this so special?

Jim Wagner:
Good question.

Nicole Gaddis:
Hi, I am Nicole Gaddis from the University of Pennsylvania. My question is for Mr. Rejeski and Dr. Schmidt. I was wondering if

there's been an opportunity to investigate the impact of educating young people before college and the impact of public perception on science advancing technologies or synthetic biology in particular?

Jim Wagner:
Got it, thank you.

Heather Latey:
I'm Heather Latey from the University of Edinboro, and I have a question for Mr. Rejeski and Dr. Schmidt as well. What do you think-- I really enjoyed your focus on comparisons from Europe and the U.S. What do you think can be learned from what has arisen in the case of genetic modification between Europe and the U.S. because this technology is going to fit into existing regulatory frameworks. What do we need to learn from what happened in the case of genetically modified crops especially…

Jim Wagner:
I'm very sorry. I didn't get good notes on that one. Slow down so I make sure I understand the question, please.

Heather Latey:
I was asking what could be learned from what has been learned between the U.S. and Europe and other countries as well in the case of existing genetic modification technologies and what can be learned going forward in synthetic biology?

Jim Wagner:
I have it, thank you.

Amy Gutmann:
Jim just wanted to hear you speak some more.

Jim Wagner:
It was beautiful. Just beautiful.

[AUDIENCE LAUGHTER]

Colleen Lyons:
Hi, my name is Colleen Lyons. I've got two questions. First is around

the Belmont report as a values discussion. So I thought it was appropriate or I'd ask you how appropriate is that as a jumping point to investigate values in today's social context. The second thing is regarding education. What role can the House of Representatives play as a platform for educating their constituents? That's a general question.

Jim Wagner:
Thank you. And finally in the back.

Donald Braman:
My name is Donald Braman, I'm a professor of Law at George Washington University.

Jim Wagner:
Yes.

Donald Braman:
And I'm a member of the Cultural Cognition Project and actually got to participate and collaborate with David Rejeski as part of the Cognition Project on some of the work they have done. I wanted to second what they said, what David and Markus said, about the potential for polarization and the need for evidence-based science communication and deliberation strategies. Maybe I'll make it a little starker than David and Markus did. Deliberation can work and bring people together if done right. But done wrong, it can really push people to the polls and create a lot of conflict and polarization. So we're lucky to have generous funding from the National Science Foundation as they are doing research on just this sort of thing. There are plenty of researchers out there looking at how to do science-based education. I just urge the commission to make evidence-based science communication a deliberate and a formal part of their report to the President.

Jim Wagner:
Appreciate that. You're with G.W. law, is that what you said?

Donald Braman:
That's right. And the Cultural Cognition Project at the law school.

Jim Wagner:
That's how we can find you. Good. I was hoping they would converge

into bins. Actually, there's at least one bin and that was around communication and education: thoughts about young people and focusing education toward them? the role of our Congress in educating constituents? And I think the comment there at the end. What about the education dimension of communications?

Gentlemen? Yes, Markus.

Markus Schmidt:
In one of our projects, in synthetic biology, we have one work package where we take film clips from Hollywood blockbuster movies that is have something to do with synthetic biology like forensic Jurassic park to find the sequence of DNA and make the dinosaur. It was science fiction in 1993 but not totally science fiction now. We take this and try to combine it with scientific facts, what is possible right now, what could be possible in the future? Should it be done? What are the consequences? And make high school packages for teachers to be used in school. I think it's one way to engage people below university grade in this area. This is a general strategy in any new technology and also people that work in climate change and try to go to schools and inform young people. They are still open. A couple of weeks ago I was invited by a school, 14 years old high school students. And it was very interesting. I gave a presentation about the synthetic genome in the cell and the children were they interested. For them it was new. But as new as any other thing that was new. Actually, it was more surprised with the teachers, why are you talking to me? Is it real or is it a joke? The children understood it's not a joke. But the teachers didn't. They were smarter in grasping this.

Jim Wagner:
Exactly. Wonderful. And options for educating Congress. And let's couple that with this question for a need for the White House office. Is that the right level? Should it have high priority here?

David Rejeski:
I think there is a tremendous need to obviously get Congress up to speed on lots of emerging technologies. I think before the congressional folks can kind of educate their constituencies, they need to get educated themselves. So the Congress uses a system called caucuses. So for years, they had the nanotechnology caucus. We worked with

them pretty intensively. And basically, they bring people in to brief members that are in the caucus. And I think that's a model that can be used with synthetic biology. One might even be able to build off the nano caucus. So I think that's a starting point. That gets the staff involved. It gets the members involved. And the caucus model is well-known in the Congress.

Jim Wagner:
Thank you.

David Rejeski:
I mean I agree that we probably don't need another White House office. But one option, since we talked about this issue of things coming together, would be to build off the coordinating office of nanotech and do nano-bio so we're not actually doing another office. We're just kind of admitting that this is where the science and technology is going. And we kind of expand that to take on some of the synthetic bio issues so we're not putting in place another White House entity, but just expanding it around this idea of converging technologies.

Jim Wagner:
Final thing we heard from the audience was the international theme and the need for — the question around the need for international standards. What can we learn about the existing conflict resolutions and agreements for genetic modification between U.S. and Europe. Perhaps we can even ask you to comment on the values of the report in this last grouping. Who wants to comment?

Paul Wolpe:
I think what you find when you look internationally and not just the United States and Europe, but for biotechnology in general, is certain areas of convergence of values in certain areas of divergence. So you have activities, you know, for example, this isn't synbio, but you have in China the genetic engineering of human nucleus into a rabbit ovum and then taking that certain number of cells, which is something that wouldn't happen in the United States. I think it is crucial as these technologies progress that we try to come to some set of international standards. While we can impose standards in our own countries and we can have multi-country agreement, it is undermined in these particular kinds of technologies, if there are rogue states, so

to speak, that are doing things that are completely outside the bounds of the regulatory system set up by treaty or by agreement or even by some kind of international regulation. And so we have a very, very difficult problem of trying to figure out how to universalize a set of standards for scientific progress, as these technologies get so much more powerful.

Markus Schmidt:
In terms of technical standards, it is incredibly important. May I remind you that one of the NASA Mars landers collapsed and they couldn't go to Mars because there was a misunderstanding between inches and centimeters which is very important. And the TARPOL project organized a meeting, a workshop, earlier this year where representatives from the U.S. and Europe were sitting together in order to talk about standards and technical standards. But if you talk about biosafety standards, I think it's also important to have these.

Also in relation to international trade, I mentioned one of the recommendations by the European group on ethics, was that the things that got imported or exported from outside the European Union, they should be acceptable and fall under the European kind of laws and regulations. They have some countries that want to import or export into the European Union have to adopt the standards and it would make incredible sense. On the other hand, I think I agree with you that standards should not limit exploration of new ideas and there should be some kind of diversity as well.

David Rejeski:
I agree with the need for the international standard setting. Let me take you in the other direction. We live in a large country and quite often, when there is some hesitancy by the federal government, state and local governments move, so the first municipality that put in place a biotechnology ordinance was Cambridge, Massachusetts. It's been in place since 1976. And there are 55 biotech companies in Cambridge. Cambridge put in place a nanotech ordinance, so did Berkeley in California, is setting up their own system to take care of nanotech issues. We know that, from air pollution control, water, whatever topic you pick, you've got a huge system. We have our own E.U. here. One of the things you have to be sensitive to is the fact some money may decide to move ahead of you. That drives industry

crazy because not only do they have to deal with this aggregation at an international level but now they're dealing with disaggregated markets at a local level. So I think it's important to keep your eye on local government and states.

Jim Wagner:
You're absolutely right. Can you get your questions answered at break time? I'd appreciate that. Let us, first of all, thank Dr. Wolpe and Schmidt and Rejeski. Thank you so much for your contribution.

[AUDIENCE APPLAUSE]

Wonderful. We will reconvene in 10 minutes, at quarter to the hour for the final session.